Impact of Investigator Disturbance on Spectacled Eiders and Cackling Canada Geese nesting on the Yukon-Kuskokwim Delta

Report to USFWS Ecological Services Office, Anchorage

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SUMMARY

We estimated the impact of investigator disturbance on spectacled eiders (*Somateria fischeri*) and cackling Canada geese (*Branta canadensis minima*) associated with nest searching and biological study camps on the Yukon-Kuskokwim Delta, Alaska. We used data from nest re-visits to estimate nest and egg mortality rate immediately following the first visit to a nest. Difference between the loss following visitation and the natural daily mortality rate estimated for previously unvisited nests measured the impact of disturbance. Three-fold increases in daily mortality rates occurred. These data provide information to predict potential impacts of localized, more intensive, nesting studies. Total loss of eggs attributable to the single search on the random plot survey sample was minimal when expressed as a percent of all YKD egg production. Visitation to nests in the random nest plot survey accounted for an additional loss of 0.04% of the cackler and 0.08% of the eider egg production for the average year from 1994-2002. This was due both to the small fraction of total nests that were visited and the small increase in nest and egg loss following nest visitation. Applying these loss rates to all other YKD eider studies, cumulative visitation effects on spectacled eiders amounted to a loss of 15 nests and 57 eggs per year.

Aerial survey observations were used to estimate and compare eider and cackler population trends in areas around semi-permanent study camps and nearby undisturbed areas. We could not demonstrate any consistent pattern of reduced population growth for areas exposed to the direct or indirect effects of study camps or investigator activity. These results confirm that cumulative population effects of nesting studies on waterfowl are small.

INTRODUCTION

Waterfowl investigations have been carried out on the Yukon-Kuskokwim Delta (YKD) since the late 1960's, with a marked increase in the intensity of activity concurrent with establishment of semi-permanent biological study camps in the mid-1980s. As an integral part of many investigations on nesting ecology, nests are visited multiple times during the egg-laying or incubation period. Incubating waterfowl usually leave their nests unattended while investigators are in the vicinity and return shortly after the perceived danger has passed. Some species may leave their nest sites when the investigator is still quite far away (>200 meters for cackling Canada geese, loons, swans, cranes) whereas others may remain on nests until investigators are within a few meters (brant, eiders). Adults may or may not cover eggs before leaving the nest. While unattended, nests are subject to predation, particularly by opportunistic Parasitic Jaegers (*Stercorarius parasiticus*), Glaucous Gulls (*Larus hyperboreus*), and occasionally Mew Gulls (*Larus canus*). Parasitic Jaegers are documented to associate with nest investigators, and jaegers and gulls will take eggs from exposed waterfowl nests when people are nearby (Strang 1980). Activity by biologists may also increase nest depredation by arctic foxes (*Alopex lagopus*) although this is not as apparent because the major activity periods of foxes is crepuscular and nocturnal. Depredation can result in total or partial loss of a clutch. Foxes are more likely to destroy complete clutches, whereas avian predators more frequently destroy only part of a clutch (Strang 1980, Sedinger 1990). Nest depredation by Long-tailed Jaeger (*Stercorarius longicaudus*) is limited to smaller species such as shorebirds and passerines. Mink, red fox, river otter, eagles, and ravens are also potential but infrequent predators of waterfowl nests on the coast of the YKD.

In addition to the specific influence of visitor-induced depredation, native Yu'pik residents of coastal villages have repeatedly expressed their concern that activities of biologists at YKD research camps and their associated equipment, such as motorboats, aircraft, observation towers, marking stakes, and tents, have a negative impact on waterfowl.

It is generally recognized among researchers that investigator disturbance to birds during nesting can have a negative impact, but this effect is usually assumed to be minimal in magnitude and unavoidable. Few quantitative estimates of the extent of detrimental effects of investigator disturbance to nesting waterfowl exist for tundra environments. Some studies demonstrate negative effects of investigator disturbance on waterfowl nesting success, whereas others show little or no effect. MacInnes and Misra (1972) attributed about half the predation losses of waterfowl eggs to human disturbance on the McConnell River (Northwest Territories). On the YKD, Mickelson (1975) also concluded that about half the accumulated nest loss may be related to disturbance in the study area. Infrequently, waterfowl will permanently abandon nests after they are disturbed. Mickelson (1975) estimated that nest trapping resulted in loss of 5% of cackler eggs due to desertion. Gulls were attracted to, and more nests were destroyed at, eider nesting islands after disturbance (Gotmark and Ahlund 1984). Sedinger (1990) immediately revisited brant nests and concluded that investigator-induced predation was negligible at the colony he studied. Investigators on the YKD in 1983 estimated that nest monitoring efforts introduced a 3-4% increase in predation on goose nests beyond that which occurred naturally, but that the increase in depredation occurred for <1% of the nesting effort on the YKD (Garrett et al. 1983, Wege and Garrett 1983). Grand and Flint (1997) marked and visited spectacled eider nests at varying schedules and found no difference in survival rates of due to observer impact.

Several studies have used artificial nests to examine factors that influence depredation. Vacca and Handel (1988) documented higher loss of simulated goose nests following visits on YKD and concluded that the visibility of exposed eggs, those not covered by nest lining materials, provided the most important cues to avian predators. Esler and Grand (1993), using artificial duck nests on Yukon Flats NWR, found that nest depredation was higher for nests visited daily, but was not affected by visitation at longer intervals. Using passerine nests artificially placed in low bushes, Major (1990) also concluded that daily visitation increased the frequency of depredation.

In some instances, predators in a local area may adopt predatory behaviors uncommon elsewhere. For example, investigators in the Hock Slough area of the YKD recently documented extensive duck egg depredation by Mew Gulls (Grand and Flint 1997), and Mew Gulls have only recently been observed depredating brant eggs at the Tutakoke colony (J. Sedinger, pers. comm.). This behavior is undocumented elsewhere on the YKD and seems to be a localized, possibly learned, behavior. Nest predation was reduced after removal of 30 and then 150 Mew Gulls over two years at the Hock Slough site, suggesting that observer impacts are likely caused by increased detection by avian predators (Grand and Flint 1997).

The loss of nests and eggs caused by visitor disturbance is best measured by an increase in mortality above the loss expected based on average daily nest and egg survival rates. The impact of nest disturbance would be overestimated by assuming that all loss occurring immediately after a nest visit was due to visitation. In contrast, underestimation of disturbance effects would occur if the calculation of "natural" daily nest survival rate were assumed to be uninfluenced by the observation process associated with collecting the data. Calculation of survival using nest exposure days (Mayfield 1975, Johnson 1979, Bart and Robson 1982, Johnson and Shaffer 1990), a procedure that appropriately corrects for bias caused by the lower detection probability of unsuccessful nests, does not correct for visitation effects. In contrast, by comparing daily mortality rates calculated from large samples of nests revisited after various intervals, Bart (1977) was able to separate visitor effects from the average daily mortality rate. For 4 of 5 species investigated, he found 3 to 12 times greater daily mortality for total nest loss, but not partial nest (egg) loss, for the day immediately following nest visitation. Therefore, without accounting for visitation bias, total nesting success can be greatly underestimated.

An estimate of the magnitude of effects of investigator disturbance may be needed for a number of reasons. Accurate, unbiased measures of reproductive success can help managers make meaningful inferences about a species population and status. Legal, political, or management-related reasons might also require understanding the impact of studying sensitive species. This was the impetus for the current study. Because of an extended period of population decline (Stehn et al. 1993), spectacled eiders were listed as a threatened species. In particular, we were interested in disturbance effects on spectacled eiders because the species has legal protection against "take". Disturbance, displacement, or any action that may reduce the survival of adults, nests, or eggs are included in provisions prohibiting take of a threatened species. Research on this species has greatly intensified over the past decade although few studies have quantified the effects of disturbance. Our primary objective was to quantify the impact of investigator disturbance on spectacled eider nest success.

We took two approaches to evaluate disturbance effects. First, using data from a random sample of plots searched once to annually estimate total nesting population size, and data from a subset of these plots that were searched twice, we estimated egg and nest loss for undisturbed (no previous visit) and disturbed (visited) nests. The difference between the two estimates was attributed to investigator disturbance. Second, we examined disturbance effects on a broader scale by using data from annual aerial surveys to compare trends in population density of breeding birds in areas with semi-permanent research camps and in areas of similar habitat without camps. If some generalized harmful influence of the study camps exists, we expected that bird populations on study areas would show a lower growth rate than those in nearby undisturbed areas. Reduced population growth might result from lower survival of adults, nests, eggs, or broods, or from a lower frequency of nesting attempts, reduced recruitment of young nesting females, or increased emigration away from study areas.

Although quantification of disturbance to spectacled eiders was the impetus for this study, we also looked at cackling Canada geese because the mechanisms by which investigators influence nesting populations may extend across species. Also, because cacklers flush from nests more readily than other goose species or eiders (Mickelson 1975), they may be more susceptible to adverse effects from human disturbance. The cackler data set is much larger, reducing the relative magnitude of sampling error and increasing our ability to measure a change attributable to disturbance.

METHODS

Sampling design and analysis of nest plot data

Each year since 1986, biologists searched a new sample of randomly located plots on YKD to estimate nesting populations and egg production of geese and eiders. Indices to nesting success, nesting chronology, and average clutch size were calculated. The number of plots (n = 43-125) and their size (0.32 - 0.45 km^2) has varied among years. In recent years, accurate and precise data has resulted with about 80 rectangular 0.32 km^2 plots searched during the middle 2 weeks of incubation. All plots were in estuarine coastal tundra habitat. Nesting cover was minimal as the vegetation was only 5-30 cm tall and still brown when plots were searched in June. Typically, 2 observers completely searched a plot in 3-8 hours depending on the density of nests and the structural complexity of lakes, islands, and shorelines. The objective was to find all eider, goose, brant, swan, crane, and gull nests. Nests of other species were recorded as encountered but many duck and most shorebird nests were missed. The numbers of nests have generally increased since 1986, particularly for cackling Canada and white-fronted geese. Because the area from which the ground plot sample was drawn has varied among years, the proportion of an aerial survey population index from areas not sampled by ground plots was used to expand the nest population estimates to the entire coastal YKD (Bowman et al. 2002). In 1994, the area to be sampled was redefined as 716 km^2 of relatively high-density aerial observations for spectacled eiders and cackling Canada geese. The stratum boundary was modified to exclude non-federal land ownership and to avoid brant nesting colonies. An average of 2,732 active nests were found each year from 1994 to 2002, including 1,271 cackler and 60 spectacled eider nests found annually (Table 1). These numbers do not include nests that were already destroyed before the time of plot search.

Using a standard data card for each nest, observers recorded species, type of nest site, whether the female or male were present or flushed from the nest, nest lining, number of eggs, stage of incubation (based on float angles), and nest status (Appendix Table 1). Observers minimized their time near the nest site, and they covered eggs with down and vegetation from the nest bowl lining before leaving. The stage of incubation can be determined by floating eggs (Westerkov 1950). As eggs decrease in density with growth of the embryo, they progress from sinking, to standing upright, to approximate equilibrium, to floating at the surface, and finally floating at an angle and rising a few mm above the water surface. The accuracy of egg floatation age is probably within about 4 days of the actual duration of incubation. The age of a destroyed nest, or a nest where no eggs were floated, was calculated as the number of days the nest was found past the average nest initiation date for all nests aged for that species and year (Bowman et al. 2002: Table 2). The accuracy of this assignment depends on the degree of synchrony in nesting chronology among all nests. For cacklers, the 90% confidence interval of hatch dates around the mean date was plus or minus 6.6 days, and for eiders, the interval was 8.2 days (Stehn, unpubl. data). Nest age equals the incubation age plus 1 day less than twice the observed clutch size, or median clutch size for destroyed nests, to account for the laying period.

From 1995 to 1999, thirty plots were double-searched to estimate nest detection rate (Table 2). Only plots that contained at least one spectacled eider nest on the first search were selected for second searches. Nests were marked during the first search using uniquely labeled tongue depressors placed in the edge of the nest bowl lining so as not to be visible to avian predators or, at a distance, to subsequent nest searchers. The marker could always be found by careful inspection and probing the edge of the nest bowl. The second search of the plot was usually made the following day by an independent crew of 2 observers that had no knowledge of the results from the first search. The average interval between plot searches was 1.4 days (n=22 at 1 day, 4 at 2 days, 3 at 3 days, and 1 plot after 4 days). In some cases the plot was subdivided and the same 2 observers independently searched the opposite half of the plot on the second day. Data from the double-searched plots enabled us to directly estimate a daily (approximately 24-hour) mortality rate for nests (total loss of clutch) and eggs (partial loss) for the period immediately following the first nest visit. Due to the small number of spectacled eider nests (n=66), we also included data from Common Eider nests (n=6). When a nest was deserted between visits (i.e., recorded as active on the first visit but with cold eggs and no adults present on second visit) we considered the nest as a total loss.

The independently twice-searched plots also provided data to estimate the detection rate of active and destroyed nests of each species (Bowman and Stehn, report in prep.). On the first visit, a large sample of nests was marked. The second crew searching the plot then recaptured a large fraction of the marked nests and also found some new nests. This allows estimation of the number of nests missed by both crews (Magnusson et al.1978), provided the assumptions implicit in the method are reasonable (see discussion by Pollock and Kendall 1987). We used the data from individual estimates of nest detection rate from each species, activity status, and nest site to derive a best-fit model of average nest detection rate with coefficients for species, activity, and nest site category. For active and destroyed nests, respectively, we used average estimates for cackler nest detection rates of 0.885 and 0.706, and for spectacled eider nests, detection rates of 0.844 and 0.673. Although destroyed nests usually do not have a bird nearby that flushes as the observer approaches to provide a cue for finding an active nest, destroyed nests remain detectable because grass and down in the nest bowl lining are quite visible, especially if strewn around by a predator or wind. We certainly expect that much lower detection rates apply for any nest destroyed during laying before down is added to the nest lining, and also for nests destroyed 2 or 3 weeks prior to search because wind and rain would remove sign of recent nesting activity.

Analysis of study camp effects using aerial survey population index data

To examine direct and indirect effects of study camps, we compared long term trends in aerial survey observations for eiders (spectacled, common, and unidentified eiders) and cackling Canada geese for areas around semi-permanent study camps and similar locations without camps. We delineated irregular polygons near camps (n=11) where nests were visited multiple times during the nesting season for several years (Fig. 1). The minimum size extended about 2 kilometers in radius around the camp location. We then defined undisturbed areas (n=11) of similar size and habitat in proximity to the camp polygons. Our intent was to make paired comparisons, although we recognize that areas are unique and that comparable areas are difficult to identify. Another set of similar non-camp control areas (n=14) were also selected for additional non-paired comparisons.

We analyzed the aerial survey observations on cackling Canada geese and spectacled eiders (unpublished USFWS data collected mainly by pilots and observers W.I. Butler, C.P. Dau, W.D. Eldridge, R.M. Platte) that were recorded over these areas. We calculated trends using indicated total birds (twice the number of singles and pairs plus birds in flocks). We used the natural log of density. Where density was 0, we substituted the natural log of a value equal to 0.1 less than the minimal observation of 2 birds (singles were doubled) divided by the area sampled. We included several years of aerial observation data before and after camp establishment. Our rationale was that, if a camp effect existed, a difference in population trend would be better detected with adequate data to smooth annual fluctuations and sampling error. Indirect effects of disturbance, such as displacement or lower recruitment, may not manifest a change in breeding pair density until several years later and reduced population growth may continue for a period even after a camp was abandoned. We plotted average slopes for each study camp and non-camp control areas. To calculate average growth rate, each area was weighted equally regardless of size, bird density, or number of years occupied.

RESULTS AND DISCUSSION

Estimated loss based on revisits to random plots

Tabulation of the number of nests found and the frequency distribution of egg numbers recorded at the first and second visit provide a direct measure of mortality (Table 3, Appendix Table 2). For cacklers, 962 nests were found twice with 22 nests (2.5%) completely destroyed and an additional 51 nests (5.7%) with fewer eggs on the second visit. For eiders (spectacled and common eiders combined), 59 nests were found twice with 3 nests (5.8%) completely destroyed and 2 nests (3.8%) with fewer eggs on the second visit. Comparable loss rates expressed per egg were 119 of 3642 eggs lost (3.3%) after the first visit for cacklers and 11 of 236 eggs (4.7%) lost for eiders (Appendix Table 2). For cacklers, 57 of the depredated eggs (1.6%) were in completely destroyed nests and 62 missing eggs (1.7%) were from nests only partially destroyed. For eiders, 8 eggs (3.4%) were in completely destroyed nests and 3 eggs (1.3%) represented partial nest loss. These average rates of loss apply to the average 1.4-day interval between the first and second visit to the 30 plots in 1995-1999.

The rate of nest and egg loss without any visitation effect must be estimated by using only data collected on the first visit, before any previous visitation impact occurs. Combining all cackling Canada goose nests (n=5,612) and spectacled eider nests (n=264) found on 310 random plots searched in the 5 years 1995 to 1999, a tabulation of the proportion of nests active and destroyed was made for each day of estimated nest age (Figs. 2 and 3). As mortality occurs throughout the nesting period, the fraction of nests remaining active when first found should decline as nest age increases. Because the observer detection rates for active and destroyed nests were not equal, more realistic numbers of nests were estimated by dividing the number found by the nest detection rate to estimate the actual number of nests. Tabulation of the data indicated that during laying and near the end of incubation, all the nests found were recorded as active nests (Figs. 2 and 3), although our sample size was small at these times. We assumed that nests destroyed during the laying period or destroyed late in incubation either cannot be found or cannot be reliably classified. To avoid these data problems, we combined all data prior to and near the onset of incubation, and we truncated the data near the time of hatch. We considered only those nests estimated at less than 25 (or 26 days for eiders) days old. The average daily rate of nest mortality was determined by weighted linear regression on the proportion of detection-adjusted number of nests active when first found versus the estimated age of the nest (Figs. 2 and 3). Average daily nest loss was 0.88% for cacklers and 1.77% for spectacled eiders. Comparable rates of daily loss of eggs were 0.86% for cacklers and 1.42% for spectacled eiders. We had expected egg mortality rate to be slightly higher compared to nest mortality. Apparently for undisturbed (not previously visited) nests the loss of single eggs to predators, such as parasitic jaegers, is very rare. Or perhaps there is a tendency for larger clutches to have higher survival rates and therefore, when expressed per egg, the average daily mortality rate per egg is reduced. Nest survival for the entire period was 0.754 for cacklers and 0.556 for eiders. Mayfield estimates of period nest survival using the same data but with number of nests adjusted for detection were 0.737 for cacklers and 0.678 for eiders (Figs. 2 and 3).

We compared the relative magnitude of daily nest and egg mortality rates for unvisited nests with the mortality rates for the period immediately after the first nest visit. Approximately a 3-fold increase was observed in the risk of total nest loss or the number of eggs lost for both cacklers and eiders (Table 3). The magnitude of increase in total nest and egg daily mortality rates were 1.6% and 2.4% for cacklers and 4.0% and 3.2% for eiders, respectively (Table 3). These losses equate to an annual average of 20 nests and 133 eggs for cacklers and 2.4 nests and 9.4 eggs for eiders for all random plots searched in a given year (Table 3). As a fraction of the total number of active nests and eggs of the YKD, the single search of plots in this sampling design caused the loss of 0.04% of the annual cackler egg production and 0.08% of the eider egg production. The possible magnitude of loss caused by repeated nest visitation on localized biological study areas could be evaluated for each specific study assuming these mortality rates apply and that each successive visit has the same impact as the first visit.

To evaluate the cumulative effects of all research and monitoring activities on spectacled eider, we extrapolated the estimated loss observed on the random plots to all nests found by all researchers in study camps sponsored by MBM, YDNWR, USGS, and UAF (Table 4). About 365 spectacled eider nests were found during each of the past few years, thus we multiplied the estimated loss of 2.4 nests and 9.4 eggs for the average of 60 spectacled eider nests found on the random plots by a factor of 6.1 to estimate a total loss of about 15 nests and 57 eggs. It should be noted that some of the camps we included in totals (Table 4) are no longer active, thus the total number of nests disturbed is currently lower.

To take this one step further – how many of these 57 destroyed eggs would have hatched and survived to join the fall population? Considering that approximately 10% of spectacled eider eggs fail to hatch because of embryonic mortality or infertility (Grand and Flint 1997), and if hatched, only 24% of ducklings would survive long enough to depart the YKD (Flint and Grand 1997, Flint et al. 2000), therefore, the 57 lost eggs approximated 57*0.90*0.24 = 12.3 fewer surviving young. If recruitment of young into the breeding population is also considered, an approximate "equivalency" between egg loss and adult breeding female mortality can be calculated. Assuming 50% of eggs are females, that first-year survival is estimated at 0.48 and after-first-year survival is estimated at 0.78 (Grand et al. - Spectacled Eider Population Model)**,** and most females do not breed until 3 yrs or older, therefore, 12.3*0.50*0.48*0.78*0.78 = 1.8 breeding females. Consequently, one could argue that the destruction of 57 eggs is roughly equivalent to the loss of 2 breeding females. This information may help establish acceptable "take" levels for research projects or other activities.

<u>Influence of study camps on population growth</u>

The average annual change in aerial survey observation density on each area provided estimates of average population growth rate for cackling Canada geese and spectacled eiders in each area (Fig. 4). Areas 7, 11, and 107 had very few or no observations of cacklers or eiders so these areas were excluded from paired comparisons. The average paired difference (n=9) in population growth rate, Control minus Study camp areas, was 0.019 ($\pm$ 0.028 SD) for cacklers and –0.044 ($\pm$ 0.071 SD) for eiders. These mean differences were not significantly different from zero. The variation among areas overshadowed any consistent pattern of difference between study camp and control areas (Fig. 4). Population growth rate comparing all areas (Fig. 5) indicated average population growth rates for study camp areas (n=10) of 0.093 ($\pm$ 0.038 SD) for cacklers and 0.104 ($\pm$ 0.067 SD) for eiders. Although camp area growth rates averaged 4.2% lower for cacklers and 4.5% higher for eiders, these were not significantly different from growth rates of similar non-camp areas (n=24) of 0.135 ($\pm$ 0.030 SD) for cacklers and 0.059 ($\pm$ 0.063 SD) for eiders. There was no indication of a long-term local adverse effect of study camps on cackler or eider populations.

MANAGEMENT IMPLICATIONS

Quantification of the impacts of investigator disturbance is important to understanding if possible benefits from research and monitoring might be offset by disturbance effects. Based on this analysis, we showed that effects of dispersed nest plot studies on spectacled eiders and cacklers were insignificant when viewed from the population perspective.

On a local scale, however, investigators should heed these findings and recognize that intrusive studies during nesting or at other times will likely result in survival rates that are biased lower than what actually occurs in undisturbed situations. The most important action biologists can take to mitigate losses is to cover exposed eggs with down and vegetation so that they are concealed well. This is based on the fact that nests with exposed eggs have higher predation than those covered with nest material (Gotmark and Ahlund 1984, Vacca and Handel 1988). Similarly, disturbance of cover around nests could, theoretically, increase the susceptibility to predators (Livezey 1980). Investigators can also minimize disturbance effects by limiting their time on study plots, which keeps some hens from returning to nests and extends the time eggs are susceptible to predators and cooling. Longer, rectangular plots may allow searchers to move through a plot more quickly than in a square plot and smaller plots would minimize the time birds are displaced from nests.

LITERATURE CITED

Bart, J. 1977. Impact of human visitations on avian nesting success. Living Bird 16:187-192.

Bart, J. and D.S. Robson. 1982. Estimating survivorship when the subjects are visited periodically. Ecology 63:1078-1090.

Bowman, T., J. Fischer, R. Stehn, and G. Walters. 2002. Population size and production of geese and eiders nesting on the Yukon-Kuskokwim Delta, Alaska, in 2002. Field report 18 July, 2002. U.S. Fish and Wildlife Service, Anchorage, AK.

Esler, D. and J. B. Grand. 1993. Factors influencing depredation of artificial duck nests. J. Wildl. Manage. 57:244-248.

Flint, P. L. and J. B. Grand. 1997. Survival of spectacled eider adult females and ducklings during brood rearing. J. Wildl. Manage. 61:217-221.

Flint, P. L. J. B. Grand, J. A. Morse, and T. F. Fondell. 2000. Late summer survival of adult female and juvenile spectacled eiders on the Yukon-Kuskokwim Delta, Alaska. Waterbirds 23:292-297.

Garrett, R. L., W. I. Butler, Jr., and M. L. Wege. 1983. An evaluation of productivity and mortality factors influencing goose populations -- a status report of the 1983 waterfowl monitoring effort on the Yukon Delta NWR, Alaska. Unpubl. report, Yukon Delta National Wildlife Refuge, Bethel, AK.

Gotmark, F. And M. Ahlund. 1984. Do field observers attract nest predators and influence nesting success of common eiders? J. Wildl. Manage. 48:381-387.

Grand, J. B. and P. L. Flint. 1997. Productivity of nesting spectacled eiders on the lower Kashunuk River, Alaska. Condor 99:926-932.

Grand, J. B., P. L. Flint, M. R. Petersen, and R. F. Rockwell. Modeling populations of spectacled eiders. Website URL: http://www.absc.usgs.gov/research/speimod/

Johnson, D. H. 1979. Estimating nest success: the Mayfield method and an alternative. Auk 96:651-661.

Johnson, D. H. and T. L. Shaffer. 1990. Estimating nest success: when Mayfield wins. Auk 107:595-600.

Livezey, B. C. 1980. Effects of selected observer-related factors on fates of duck nests. Wildl. Soc. Bull. 8:123-128.

MacInnes, C. D. and R. J. Misra. 1972. Predation on Canada goose nests at McConnell River, Northwest Territories. J. Wildl. Manage. 36:414-422.

Magnusson, W. E., G. J. Caughley, and G. C. Grigg. 1978. A double-survey estimate of population size from incomplete counts. J. Wildl. Manage. 42:174-176.

Major, R. E. 1990. The effect of human observers on the intensity of nest predation. Ibis 132:608-612.

Mayfield, H. 1975. Suggestions for calculating nest success. Wilson Bull. 87:456-466.

Mickelson, P. G. 1975. Breeding biology of Cackling geese and associated species on the Yukon-Kuskokwim Delta, Alaska. Wildl. Monogr. No. 45. 35pp.

Pollock, K. H., and W. L. Kendall. 1987. Visibility bias in aerial surveys: a review of estimation procedures. J. Wildl. Manage. 51:502-510.

Sedinger, J. S. 1990. Effects of visiting black brant nests on egg and nest survival. J. Wildl. Manage. 54:437-443.

Stehn, R.A., C.P. Dau, B. Conant, and W.I. Butler, Jr. 1993. Decline of spectacled eiders nesting in western Alaska. Arctic 46:264-277.

Strang, C. A. 1980. Incidence of avian predators near people searching for waterfowl nests. J. Wildl. Manage. 44:220-222.

Vacca, M. M. and C. M. Handel. 1988. Factors influencing predation associated with visits to artificial goose nests. J. Field Ornith. 59:215-223.

Wege, M. and R. L. Garrett. 1983. An evaluation of productivity and mortality factors influencing goose populations -- a status report of the 1983 waterfowl monitoring effort at Kigigak Island, Alaska. Unpubl. rpt, Yukon Delta National Wildlife Refuge, Bethel, AK.

Westerkov, K. 1950. Methods for determining age of game bird eggs. J. Wildl. Manage. 14:56-67.

Table 1. Total number of active nests found each year in searching randomly-located plots established to sample 716 km^2 of high-density goose and eider nesting habitat on the coast of the Yukon-Kuskokwim Delta.

Species	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	1994-2002 average
Cackling Canada Goose	625	1382	1080	1226	1602	1113	1672	1207	1534	1271
White-fronted Goose	222	315	349	368	392	263	493	418	455	364
Black Brant	274	195	110	124	488	156	547	311	424	292
Emperor Goose	328	307	299	240	281	247	351	165	330	283
Shorebird spp	55	72	71	76	67	88	92	113	98	81
Glaucous Gull	54	71	26	83	116	39	134	86	96	78
Spectacled Eider	35	66	54	57	69	56	71	54	81	60
Pacific & Red-throated Loon	29	44	17	33	56	63	62	57	65	47
Dabbling duck spp	21	36	21	10	82	34	49	30	40	36
Mew Gull	27	44	21	9	40	36	37	36	64	35
Sabine's Gull	38	22	20	15	44	28	28	44	47	32
Tundra Swan	27	23	31	35	42	20	33	30	40	31
other spp	24	27	22	12	32	30	35	48	49	31
Sandhill Crane	32	31	37	34	35	16	35	13	40	30
Common Eider	14	17	21	24	32	17	28	33	26	24
Arctic Tern	8	17	6	5	21	16	10	25	58	18
diving duck spp	17	28	12	12	25	15	31	7	12	18
Total nests	1830	2697	2197	2363	3424	2237	3708	2677	3459	2732
Number of plots	43	50	54	75	72	59	80	81	84	
Sample area (sq km)	715.7	715.7	715.7	715.7	856.6	856.6	715.7	715.7	715.7	

Table 2. Total number of nests found by observers on the first and second independent searches of randomly-located sample plots.

			First plot search				Second plot search				
year	**plot**	**date 1**	**obsvr1**	**obsvr2**	**obsvr3**	**sum 1**	**date 2**	**obsvr4**	**Obsvr5**	**sum 2**	**Days apart**
1995	**50**	6-04-95	11	27		38	6-05-95	25	21	46	1
1995	**7**	6-05-95	44	48		92	6-06-95	38	44	82	1
1995	**76**	6-05-95	25	32		57	6-07-95	37	22	59	2
1995	**79**	6-06-95	35	49		84	6-07-95	58	36	94	1
1995	**63**	6-07-95	65	54		119	6-08-95	80	53	133	1
1995	**6**	6-08-95	25	36		61	6-12-95	38	26	64	4
1995	**8**	6-08-95	22	31		53	6-09-95	33	21	54	1
1995	**25**	6-10-95	51	22		73	6-11-95	37	20	57	1
1995	**70**	6-10-95	30	28		58	6-11-95	37	37	74	1
1995	**20**	6-14-95	46	54		100	6-15-95	64	34	98	1
1995	**40**	6-14-95	29	27		56	6-15-95	28	28	56	1
1995	**29**	6-15-95	17	17		34	6-16-95	19	13	32	1
1995	**27**	6-16-95	62	85		147	6-17-95	80	57	137	1
1996	**59**	6-01-96	17	31	12	60	6-03-96	32	27	59	2
1996	**3**	6-04-96	17	14		31	6-07-96	25	12	37	3
1996	**25**	6-04-96	36	48		84	6-07-96	32	39	71	3
1996	**57**	6-09-96	25			25	6-12-96	26		26	3
1996	**80**	6-12-96	12	20		32	6-13-96	12	22	34	1
1997	**63**	6-02-97	35	53		88	6-03-97	39	44	83	1
1997	**70**	6-05-97	34	36		70	6-07-97	44	32	76	2
1998	**4**	6-10-98	40	68		108	6-11-98	69	49	118	1
1998	**58**	6-11-98	21	8		29	6-13-98	21	10	31	2
1998	**53**	6-14-98	21	47		68	6-15-98	23	44	67	1
1998	**2**	6-15-98	11	25		36	6-16-98	13	23	36	1
1999	**31**	6-16-99	18	31		49	6-17-99	20	19	39	1
1999	**34**	6-16-99	22	27		49	6-17-99	21	18	39	1
1999	**79**	6-16-99	35	61		96	6-17-99	34	50	84	1
1999	**113**	6-16-99	44	64		108	6-17-99	40	45	85	1
1999	**55**	6-19-99	22	15		37	6-20-99	24	14	38	1
1999	**30**	6-23-99	10	9		19	6-24-99	15	7	22	1

Table 3. Comparison of nest and egg mortality rates for cackling Canada geese and eiders within the average duration of 1.4 days following the first visit to a nest compared to daily loss rates estimated prior to any visit. Average nest and egg numbers for cackling Canada geese and eiders are from the random plot survey data for 1994 to 2002 as tabulated by Bowman et al. (2002).

Species:	Cackler	Cackler	Eider	Eider
Mortality of:	Nests	Eggs	Nests	Eggs
Total nest loss after visitation	0.0247	0.0157	0.0577	0.0339
Partial nest loss after visitation	0.0573	0.0170	0.0385	0.0127
Sum	0.0820	0.0327	0.0962	0.0466
Daily mortality rate without visitation	0.0088	0.0086	0.0177	0.0142
Multiplication factor for risk of nest or egg loss	2.81	3.80	3.26	3.28
Increase in mortality rate following a visit	0.0159	0.0241	0.0400	0.0324
Average number of active nests found per year and active eggs per nest	1271	4.35	60	4.85
Average loss caused by random plot sampling	20	133	2.4	9.4
Average total nests and eggs estimated for YKD	74,283	326,592	2,534	12,406
Percent loss caused by random plot sampling	0.027%	0.041%	0.095%	0.076%

Table 4. Estimated numbers of active spectacled eider visited by investigators on Yukon Delta National Wildlife Refuge, 1995-99.

Study or Study Area	Average no. of active SPEI nests visited annually
YKD random nest plots	60
Kigigak Island	110
Aknerkochik	10
Big Slough	30
Tutakoke	30
Hock Slough	100
Old Chevak	5
Incidental encounters	20
TOTAL	365

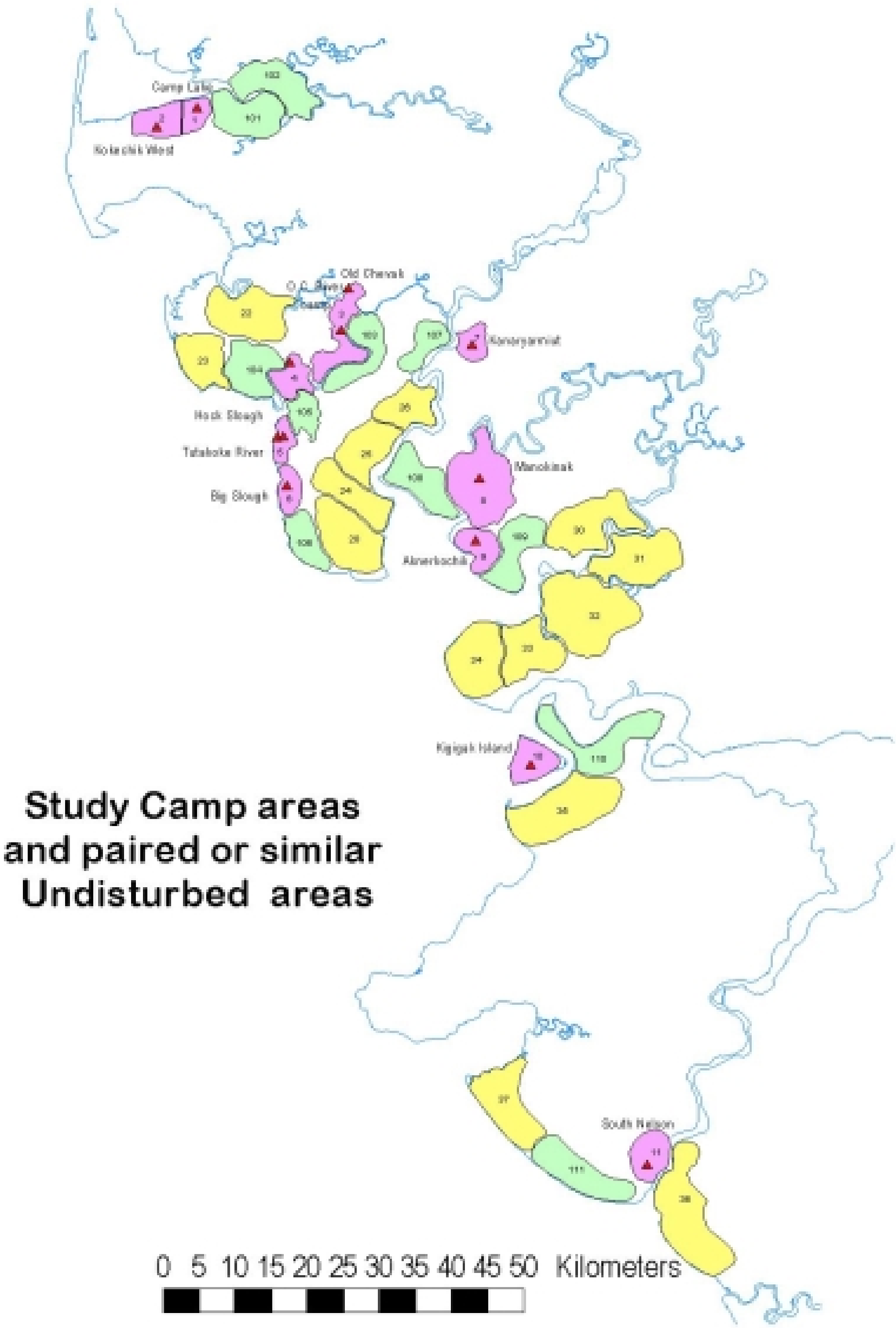
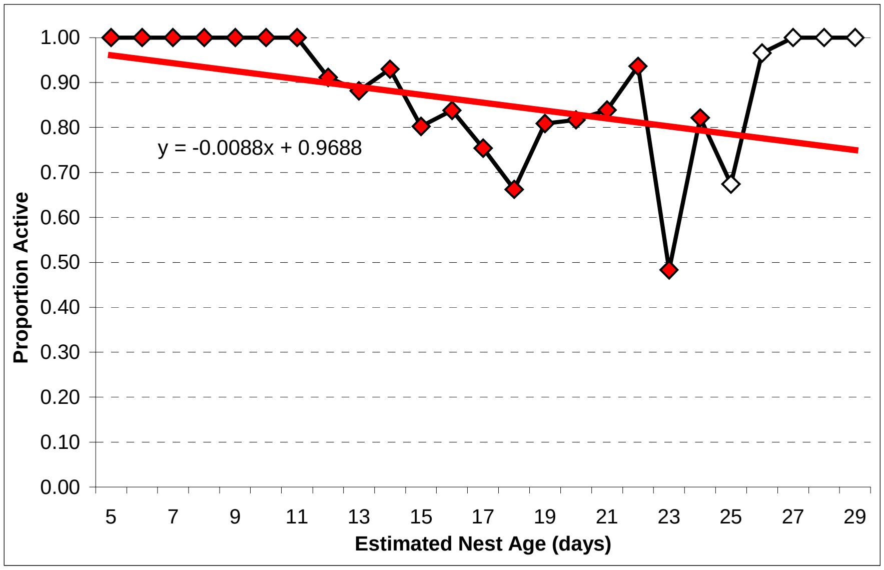


Figure 1. Locations of semi-permanent study camps (1-11), adjacent paired control areas (101-111), and similar undisturbed control areas (22-37).

spp = CCGO year(s) = 1995-1999



nest age	nests active	nests destroy
laying	1	0
6	55	0
7	8	0
8	16	0
9	32	0
10	10	0
11	28	0
12	155	12
13	242	26
14	1064	64
15	173	34
16	286	44
17	307	80
18	241	98
19	445	84
20	212	38
21	306	47
22	1050	57
23	129	110
24	219	38
25	*127*	*49*
26	*388*	*11*
27	*23*	*0*
28	*76*	*0*
30+	*19*	*0*
sum =	5612	792

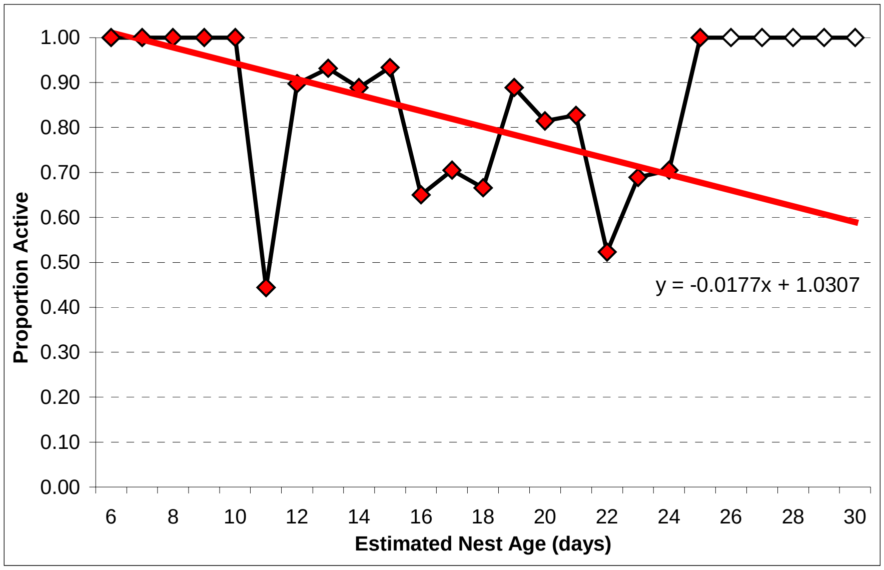
spp =	**CCGO**
year(s) =	**9599**
median clutch size =	**4**
laying period =	**7**
incubation period =	**25**
total period length =	**32**

	active	destroyed
Detection rate	**0.8848**	**0.7055**
n Nests	5612	792
adj n Nests	6342.6	1122.7
n Eggs	24179	2998
adj n Eggs	27326.7	4249.8

	nests	adj Nests	eggs	adj Eggs	partial n-e
intercept day 0 =	1.0104	**1.0040**	1.0198	1.0149	
slope (change per day) =	-0.0078	**-0.0088**	-0.0076	-0.0086	
SE slope =	0.0056	**0.0063**	0.0052	0.0059	
daily survival rate =	0.9922	**0.9912**	0.9924	0.9914	-0.0002
period survival =	0.7795	**0.7539**	0.7836	0.7585	-0.0045
apparent nest success =	0.8718	**0.8443**	0.8855	0.8605	-0.0161
Mayfield nest success =	0.7811	**0.7374**	0.8037	0.7635	-0.0260

Figure 2. Proportion of Cackling Canada Goose nests active when first found on nest plots searched on the YKD, 1995 to 1999. Nest numbers were adjusted upwards to account for incomplete and unequal detection rates between active and destroyed nests. Linear least-squares regression, as weighted by the total number of nests at each age, estimated average daily mortality rate for nests (as shown) and also eggs (not shown). This daily rate was expanded to calculate total period survival. The apparent survival rate and Mayfield estimates of nest survival were calculated to provide a comparison with the weighted linear regression method.

spp = SPEI year(s) = 1995-1999



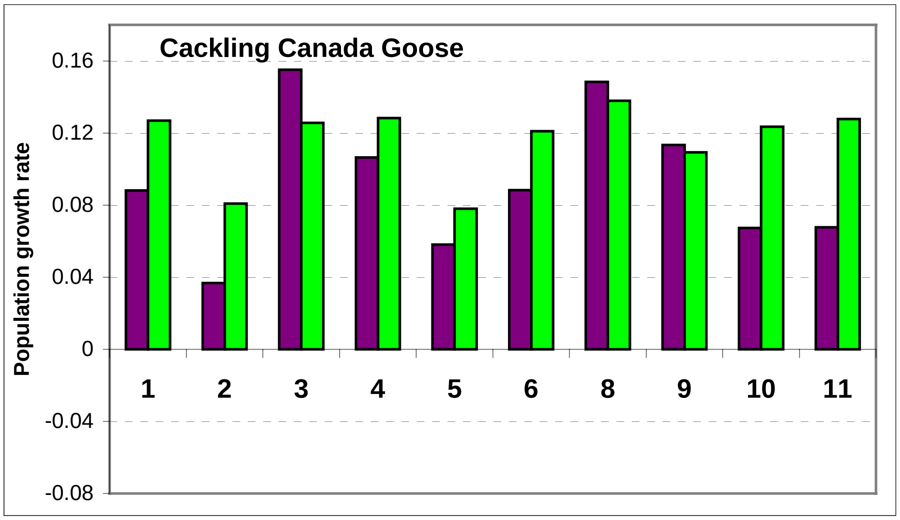
nest age	nests active	nests destroy
laying	1	0
7	28	0
8	1	0
9	1	0
10	9	0
11	3	3
12	11	1
13	17	1
14	10	1
15	70	4
16	7	3
17	6	2
18	10	4
19	10	1
20	11	2
21	6	1
22	11	8
23	25	9
24	3	1
25	8	0
26	*2*	*0*
27	*5*	*0*
28	*2*	*0*
29	*6*	*0*
30+	*1*	*0*
sum =	264	41

spp =	**SPEI**
year(s) =	**9599**
median clutch size =	**5**
laying period =	**8**
incubation period =	**25**
total period length =	**33**

	active	destroyed
Detection rate	**0.8443**	**0.6732**
n Nests	264	41
adj n Nests	312.7	60.9
n Eggs	1259	152
adj n Eggs	1491.1	225.8

	nests	adj Nests	eggs	adj Eggs	partial n-e
intercept day 0 =	1.1036	**1.1190**	1.0828	1.0985	
slope (change per day) =	-0.0152	**-0.0177**	-0.0120	-0.0142	
SE slope =	0.0052	**0.0059**	0.0050	0.0056	
daily survival rate =	0.9848	**0.9823**	0.9880	0.9858	-0.0034
period survival =	0.6039	**0.5556**	0.6712	0.6230	-0.0674
apparent nest success =	0.8581	**0.8283**	0.8872	0.8624	-0.0342
Mayfield nest success =	0.7284	**0.6778**	0.7834	0.7400	-0.0622

Figure 3. Proportion of Spectacled and Common Eider nests active when first found on nest plots searched on the YKD, 1995 to 1999. Nest numbers were adjusted upwards to account for incomplete and unequal detection rates between active and destroyed nests. Linear least-squares regression, as weighted by the total number of nests at each age, was used to estimate daily mortality rate for nests (as shown) and also eggs (not shown). This daily rate was expanded to calculate total period survival. The apparent survival rate and Mayfield estimates of nest survival were calculated to provide a comparison with the weighted linear regression method.



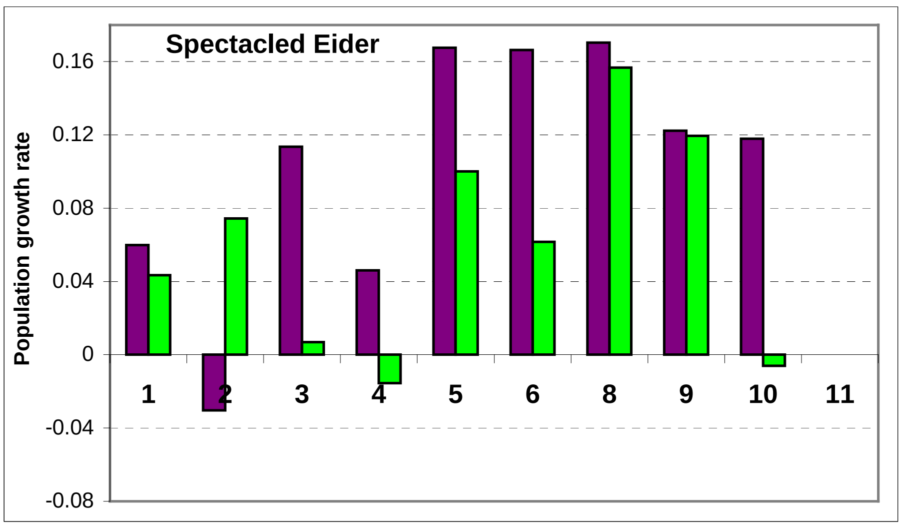
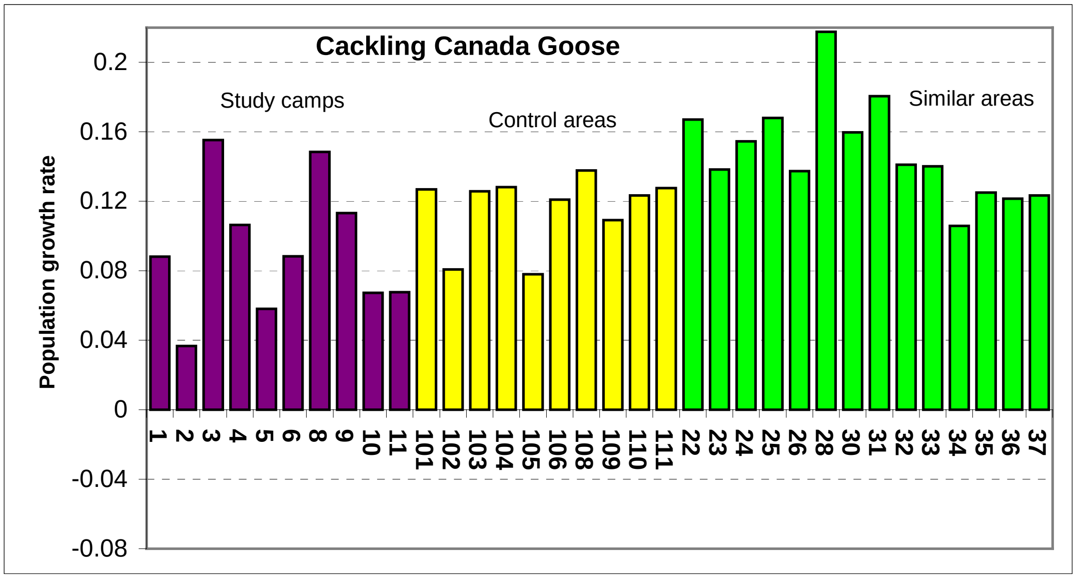


Figure 4. Population growth rate of cackling Canada geese (1985-2002) and spectacled eiders (1988-2002) observed on aerial survey transects sampling study camp areas (dark columns) and adjacent control areas (light columns). See Figure 3 for locations of paired geographic areas indicated by numbered bars.



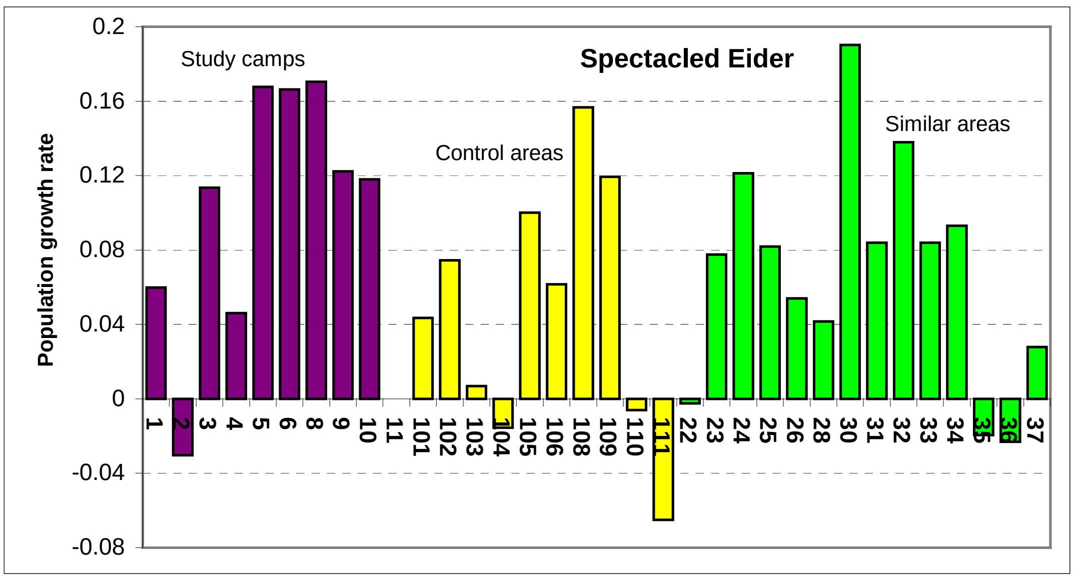


Figure 5. Population growth rates of cackling Canada geese (1985-2002) and spectacled eiders (1988-2002) observed on aerial survey transects sampling study camp areas (left, dark columns), similar unpaired areas (central, light columns), and adjacent paired control areas (right, medium shade columns). See Figure 3 for locations of paired geographic areas indicated by numbered bars.

Appendix Table 1. Information and data codes recorded on nest cards during nest plot searches on the Yukon Delta NWR.

YR	Year	98
MO	Month	5=May, 6=June, 7=July
DAY	Day of the month	01, 07, 12, 26, 30
OBS	Observer	2 letter initials (first and last name) of each observer.
PT	Plot type	R - random R2 - second search of random plot X - incidental, off plot
PLOT	Plot#	up to 4 digit numbers
NEST#	Nest Number	up to 4 digit numbers
SPP	Species	4 letter code- CCGO, EMGO, WFGO, BRAN, DUNL
SITE	Nest site	**I**-island **P**-peninsula **S**-shoreline of pond **MI**- island in exposed mud **L**-slough bank **G**-grass meadow **N**-pingo **U**-upland ridge **W**-willow shrub **D**-displaced island
F	female	**F** - flushed from nest **P** - present at or near nest site **O** or blank - not observed
M	male	Same codes as female, if a second bird is present.
NL	nest lining	**G** - grass only **D** - down or feathers present (with grass) **S** - scrape, hollow, or platform
PrevObs	Previous observer of marked nest (for R2 plots only) - 2-letter initials	
PrevNest#	Previous nest number of marked nest (for R2 plots only)	

NS **nest status**

"blank" - checked, no sign of loss, normal, active nest
I - inactive, nest abandoned, cold eggs, **no down**, no obvious predation
D - deserted, cold eggs, previously active, **down present**,
predation may have occured since nest was deserted
Q - questionable or indirect visit, contents not inspected
X - destroyed, partial or total egg loss to predators (∃1 egg destroyed)
(Use the X code unless you have strong evidence of a specific predator)
M - mammalian predation suspected
A - avian predator suspected, pecked hole in egg shell
J - jaeger observed at destroyed nest
L - gull observed at destroyed nest
F - fox seen at destroyed nest, or definite fox sign at destroyed nest
K - mink seen or eggs found eaten in mink runway
H - human disturbance prior to nest visit probably caused nest loss,
e.g., nearby camp or tower, previous unrecorded visits
Y - subsistence egging suspected, footprints to nest
B - biologists searching suspected to have caused nest loss,
e.g., jaegers pecked eggs just before the actual nest visit
W - water destroyed the nest by flood tide
P - parent bird killed by predator, carcass or feathers nearby
Z - parent bird found dead near nest, no sign of predation

EGG **egg status** (THERE SHOULD BE AN ENTRY FOR EVERY EGG IN NEST)

Stages 1-9 (see diagram of float angles on nest card)
E - egg normal, OK, active
B - broken shell piece in or near nest, predation, not hatched
C - cold egg (not cool), not incubated; laying or deserted nest
R - dump egg based on odd size, same or different species
F - deformed or small sized egg
O - out of nest
V - visiting observer accidently destroyed egg
A - addled, dead young in egg, abnormal float angle
D - dead gosling (nestling) in nest
P - pipping, including peeping and star-pipped eggs
M - membrane - definite large piece (possibly with a fecal sac)
H - hatched young in or near nest
N - nestling - altricial passerine young in nest
X - missing, probably taken or destroyed by predator

Appendix Table 2. Tabulation of the number of nests with specific numbers of eggs on the first and second visit on plots intensively searched by 2 independent crews of 2 observers with a 1-4 day interval between visits.

Cackling Canada Goose

Number of nests recorded with clutch size of:

		second visit number of eggs											
		0	1	2	3	4	5	6	7	8	9	10	
first visit number of eggs	0	72	0	0	0	0	0	0	0	0	0	0	
	1	5	12	0	0	0	0	0	0	0	0	0	
	2	6	2	47	0	0	0	0	0	0	0	0	
	3	7	1	6	112	6	0	0	0	0	0	0	
	4	2	1	1	11	185	8	0	0	0	0	0	
	5	1	0	1	2	15	296	8	1	0	0	0	
	6	1	0	0	0	3	7	120	2	0	0	0	
	7	0	0	0	0	0	0	1	19	0	0	0	
	8	0	0	0	0	0	0	0	0	1	0	0	
	9	0	0	0	0	0	0	0	0	0	0	0	
	10	0	0	0	0	0	0	0	0	0	0	0	962
found only on 2nd visit		24	2	15	15	30	32	13	4	1	0	0	136
found only on 1st visit		0	40	6	3	21	38	30	13	3	0	0	154

136	12.19%	NEW nests found on second search
154	13.80%	nests NOT found on the second search
962	76.84%	nests found BOTH times
96	8.60%	nests with 0 eggs when first found

Considering only those nests with eggs that were visited twice:

3523	96.73%	eggs unchanged in	**792**		nests with equal clutch at both visits
26	0.71%	eggs added in	**25**	2.81%	nests with egg gain
119	3.27%	eggs lost after first visit in	**73**	8.20%	nests with egg loss
57	1.57%	loss of eggs (total nest loss) in	**22**	2.47%	nests with complete loss at second visit
62	1.70%	loss of eggs (partial nest loss) in	**51**	5.73%	nests with partial loss at second visit
3642		total eggs at first visit	890		total nests visited twice

Appendix Table 2 (continued).

Spectacled and Common Eider

Number of nests recorded with clutch size of:

		second visit number of eggs											
		0	1	2	3	4	5	6	7	8	9	10	
first visit number of eggs	0	**7**	0	0	0	0	0	0	0	0	0	0	
	1	**1**	**1**	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	0	
	3	**1**	0	**1**	**2**	0	0	0	0	0	0	0	
	4	**1**	0	0	0	**7**	**1**	0	0	0	0	0	
	5	0	0	0	0	0	**18**	**2**	0	0	0	0	
	6	0	0	0	0	0	0	**15**	0	0	0	0	
	7	0	0	0	0	0	0	0	0	0	0	0	
	8	0	0	0	0	0	0	0	0	0	0	0	
	9	0	0	0	0	0	0	0	**1**	0	0	0	
	10	0	0	0	0	0	0	0	0	0	0	**1**	59
found only on 2nd visit		4	0	0	2	1	2	2	0	1	0	0	12
found only on 1st visit		0	5	1	2	1	2	2	3	1	0	0	17

12	15.79%	NEW nests found on second search
17	22.37%	nests NOT found on the second search
59	67.05%	nests found BOTH times
11	14.47%	nests with 0 eggs when first found

Considering only those nests with eggs that were visited twice:

225	95.34%	eggs unchanged in	**44**		nests with equal clutch at both visits
3	1.27%	eggs added in	**3**	5.77%	nests with egg gain
11	4.66%	eggs lost after first visit in	**5**	9.62%	nests with egg loss
8	3.39%	loss of eggs (total nest loss) in	**3**	5.77%	nests with complete loss at second visit
3	1.27%	loss of eggs (partial nest loss) in	**2**	3.85%	nests with partial loss at second visit
236		total eggs at first visit	52		total nests visited twice